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SIGN OR GROUP LENGTH FEET (meter)	NUMBER OF LUMINARIES	DISTANCE OF FIRST LUMINAIRE FROM LEFT EDGE FEET (meter)	DISTANCE BETWEEN LUMINAIRES FEET (meter)
58.5 (17.55 m)	7	2.25 (0.675 m)	9.0 (2.7 m)
59.0 (17.70 m)	7	2.50 (0.75 m)	9.0 (2.7 m)
59.5 (17.85 m)	7	2.75 (0.825 m)	9.0 (2.7 m)
60.0 (18.00 m)	7	3.0 (0.90 m)	9.0 (2.7 m)

SECTION 660

TRAFFIC SIGNALS

660.1-DESCRIPTION:

This work shall consist of furnishing and installing various types of traffic signal systems. It shall include, but not be limited to, traffic signals and traffic signal interconnection systems to be installed in accordance with this Specification, as shown on the Plans or as directed by the Engineer.

All electrical work shall conform to current requirements of the *National Electrical Code*, latest edition, all local codes and Section 631 of the Standard Specifications.

All details not specified or not shown on the Plans shall conform to the requirements of the latest issue of the *Manual on Uniform Traffic Control Devices*, (referred to as the MUTCD). This Manual is published by the Federal Highway Administration of the U.S. Department of Transportation and supplemented by the publication "Official Ruling on Request" and the West Virginia Division of Highways Traffic Engineering Division Directives.

660.2-MATERIALS:

All materials shall be new and shall conform to the requirements of the following subsections of 715.42, Traffic Signals.

MATERIALS	SUBSECTION
Pre-Timed, Fixed Cycle Traffic Signal Controllers	715.42.1
Solid State Traffic Actuated Signal Controllers	715.42.2
Traffic Adjusted Master Controller (Type OPV)	715.42.3
Local Coordinating Units	715.42.4
Traffic Detectors	715.42.5

MATERIALS	SUBSECTION
Adjustable Face Signal Heads	715.42.6
Auxiliary Traffic Signal Equipment	715.42.7
Cabinets	715.42.8
Signal Supports	715.42.9
Electrical Conduit	715.42.10
Junction Boxes	715.42.11
Messenger Cable	715.42.12
Conductors	715.42.13
Supplemental Flashing Beacons & Mountings	715.42.14

Within 15 day following the award of the Contract, the Contractor shall submit to the Engineer a list of equipment and materials which the Contractor proposes to install. The list shall be complete as to the name of manufacturer, size, and identifying number of each item. The list shall be supplemented by such other data as may be required, including detailed scale drawings and wiring diagrams of any special equipment. A signed statement shall accompany the materials list stating that the materials meet the applicable requirements of these Specifications.

CONSTRUCTION METHODS

660.3-GENERAL:

Construction methods shall conform to the requirements of the Plans and the latest issue of the West Virginia Division of Highways Standard and Supplemental Specifications, except as modified.

660.4-MAINTAINING TRAFFIC:

During the installation of traffic signals and appurtenances, the roadway shall be kept open to all traffic by the Contractor in such a way that both local and through traffic will be adequately and safely accommodated through the work area. See the Manual, "Traffic Control for Street and Highway Construction and Maintenance Operations", and applicable sections of the Standard Specifications.

660.5-REMOVING EXISTING SIGNAL EQUIPMENT:

Existing traffic signal equipment at the intersection shall be removed by the Contractor. If there is not a pay item in the proposal, the Contractor shall

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remove the signal heads, controller and poles and render the equipment unusable as traffic control devices. If there is a pay item in the Proposal for signal removal, the Contractor shall remove the controller, signal heads, hardware and poles, if required, in such a manner so as not to damage the equipment. These heads, controllers and poles shall be turned over to the Engineer and become the property of the Division. Salvaged wire and conduit shall become the property of the Contractor.

When a foundation is to be abandoned, the top of foundation, anchor bolts, and conduits shall be removed to a depth of not less than 6 inches (150 mm) below the surface of the sidewalk or unimproved ground. The resulting hole shall be backfilled with material equivalent to the surrounding material.

660.6-REMOVING AND REPLACING IMPROVEMENTS:

Existing improvements, such as sidewalks, curbs, gutter, portland cement and asphalt concrete pavement, underlying material, lawns and plants, and any other improvements removed, broken or damaged by the Contractor's operations, shall be replaced or reconstructed with the same kind of material as found on the work or with materials of equal quality. The new work shall be left in a serviceable condition.

Whenever a part of a square or slab of existing concrete sidewalk, curb, gutter, or driveway is broken or damaged, the entire square, section or slab shall be removed and the concrete reconstructed as specified above.

The outline of all areas to be removed in portland cement concrete sidewalks and driveways and in pavements shall be cut to a minimum depth of 2 inches (50 mm) with an abrasive-type saw prior to removing the sidewalk, driveway and pavement material. Cuts shall be neat and true with no shatter outside the removal area.

660.7-EXCAVATING AND BACKFILLING:

Excavations required for the installation of foundations, conduit and other appurtenances shall be performed in such a manner as to avoid any unnecessary damage to streets, sidewalks, landscaping, and other improvements. Pavement cuts and excavations shall be no wider than necessary for the proper installation of the electrical appurtenances and foundations, or as required for the proper replacement of pavements or other improvements.

Excavation shall not be performed until immediately before installation of conduit, foundations or other appurtenances. The material from the excavation and the equipment used in the excavation shall be placed in a position that will least interfere with surface drainage and that will least obstruct vehicular and pedestrian traffic.

At the end of each day's work, and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from the portion of the roadway open for use by vehicular and pedestrian traffic. All surplus excavation material shall be removed and disposed of, within 48 hours, outside of the highway right-of-way, unless otherwise directed by the Engineer.

All excavations shall be backfilled with suitable random material in horizontal layers not to exceed 4 inches (100 mm) after compaction. When the trench width is less than 12 inches (300 mm), each lift shall be compacted to the satisfaction of the Engineer. Testing is not required. When the trench width is 12 inches (300 mm) or greater, each lift shall be compacted to 95 percent of the maximum dry density. All surplus material shall be removed from the right-of-way and the backfill finished flush with surrounding natural ground, including replacement of any damaged facilities or appurtenances. The Contractor shall restore all areas disturbed by this excavation or other operations to their original conditions including grading, seeding, mulching and fertilizing as directed by the Engineer.

660.8-FOUNDATIONS:

Foundations for controller cabinets and signal support structures shall be of Class B portland cement concrete and shall be proportioned, mixed and placed in accordance with Section 601 of the Standard Specifications or as specified.

All reinforced material used in signal support structures shall be in conformation with Sections 602 and 709 of the Standard Specification.

The Contractor shall inform the Engineer when the excavation is complete and no concrete shall be placed until the Engineer has approved the excavation for each individual foundation. No foundation shall be set over recent fill of extensive depth or muck except by the approval of the Engineer. For foundations set in solid rock see Standard Details.

Foundations shall conform to the sizes and shapes shown on the Plans and shall be monolithic. Forms shall be used for the top 12 in. (300 mm) of a foundation; they shall be true to line and grade and securely braced in place. Tops of foundations shall be finished to curb or sidewalk grade or as directed by the Engineer.

When embedded poles are used, a pre-cast concrete block or concrete cast in place 24 hours before setting the pole, shall be set in the bottom of the foundation excavation as shown on the Standard Detail sheet. Suitable anchoring devices to hold the embedded pole in the proper positions, until the surrounding concrete has set for at least 12 hours, must be provided. These devices must be approved by the Engineer and the pole shall not be allowed to be set without such devices.

Anchor bolts shall be accurately set in accordance with a detail furnished by the pole manufacturer. Conduit ends and anchor bolts shall be held in the proper position and to the proper height by means of a template until the concrete sets.

Forms shall be oiled and excavation surfaces that come in contact with the concrete shall be thoroughly moistened before concrete placement. Forms shall not be removed until the concrete has thoroughly set.

Ordinary surface finish as described in Section 601 of the Standard Specifications shall be applied to exposed surfaces of concrete.

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All concrete foundations shall be allowed to set for 72 hours before any support structures are installed.

Support structures shall be plumb or raked as directed by the Engineer.

Foundations for wooden poles shall be excavated to dimensions slightly larger than the pole diameter and the excavation around the pole shall be backfilled with suitable random material in horizontal layers not to exceed 4 inches (100 mm) after compaction. Each lift shall be compacted to the satisfaction of the Engineer. Testing is not required.

Depth of the pole foundation shall be as specified on the Plans. A device to hold the wooden pole in place with the proper rake until backfilling is complete shall be provided. Blocks wedged between the excavation and the pole are not acceptable.

Ground rods shall be $\frac{3}{4}$ inch in diameter with a minimum length as shown on the Plans and shall be one piece. Sectional or segmented ground rods are not permitted. All signal supports shall have ground rods. The ground rods shall be complete with ground clamp and square head bolt.

660.9-LOOP TRAFFIC DETECTORS:

Installation shall conform to the details and notes shown on the Plans.

Slots cut in the pavement for the loop conductor shall be neat and true to the dimensions shown on the Plans. Slots shall be blown out and dried before loop conductors are installed.

The # 14 THWN stranded loop conductor shall run continuous and unspliced from the roadway loop to a junction box or conduit as indicated in the Plans. Each loop shall consist of a single separate wire and shall be connected to the detector by a separate lead-in wire. The loops shall consist of three turns of wire, unless otherwise specified.

All loop wire installation shall be made without damage to the wire or its insulation and all damaged wires shall be replaced. The wire must be so placed that there are no kinks or curls and no straining or stretching of the insulation.

It shall be installed and secured as deep in the slot as possible. A blunt object, similar to wooden paint stirrer shall be used to seat the loop wire. A screwdriver or other sharp tool shall not be used for this purpose.

Prior to placing the loop slot sealant, the loop wire shall be checked for continuity, resistance and insulation integrity. Insulation integrity shall be checked by applying a megger between each end of the loop wire and the nearest reliable electrical-ground street light, fire hydrant, etc. If no available ground exists, a suitable ground shall be established for the measurement, (e.g., driven metal spike). The megger reading shall be in excess of ten megohms under all conditions, (500 volts DC). The continuity and megger checks shall be recorded by the Engineer.

Lead-in wire from the loop conductor to the detector terminal strip shall be two # 14 AWG solid copper.

The lead-in wire shall also be continuous and unspliced from junction box or conduit to the detector terminal strip in the cabinet.

Splices between the loop conductor and the lead-in wire shall be soldered

with fuseable metal or alloy. These splices shall first be joined and made mechanically secure and tested electrically. No spring connectors will be allowed for splicing. When the mechanical connection has been shown to be electrically functional under operational conditions, it shall then be soldered. Each splice shall then be insulated with a permanent, waterproof covering as specified or as approved by the Engineer. Waterproof adhesive shall be applied to the splice and on at least 2 inches (50 mm) of loop wire and lead-in wire insulation on both sides of the splice. The splice shall then be covered with half-lapped, $\frac{3}{4}$ in. (19 mm), self-bonding electrical tape; starting at the center of the splice and proceeding to $\frac{3}{4}$ in. (19 mm) onto the wire insulation, returning to the center of the splice. The entire splice shall then be wrapped with half-lapped, $\frac{3}{4}$ in. (19 mm), all-weather electrical tape using the same procedure as above. When both ends of the loop wire and lead-in wires are so spliced and wrapped, both splices shall then be wrapped together with $\frac{3}{4}$ in. (19 mm), all-weather electrical tape. The entire splice area to the end of the adhesive coating shall be covered. The splice shall then be completed by inserting a four-inch (100 mm) piece of all-weather electrical tape into the "V" formed by the loop wires.

The loop slot cuts in the pavement shall be filled with a permanent, flexible weatherproof sealant after the placement of the loop wire in the slots. The sealant shall be resistant to traffic, water, gasoline, chemical fumes, mild alkalis, oils and mild acids; no noticeable deterioration of the sealant shall be apparent after exposures to temperatures ranging from minus 20° F (-6° C) to plus 160° F (71° C). Before sealing the loop, slots must be clean and dry and blown out with oil-free air. The sealant shall be placed to within $\frac{1}{8}$ in. (3 mm) of the pavement surface and surplus sealant shall be removed from the adjacent road surfaces without the use of solvents.

The loop slot sealant shall be of "Weatherban 101 Sealer" as manufactured by the 3-M Company or an approved equal.

660.10-SIGNAL HEADS:

All signal heads shall be either plumb or level, symmetrically arranged, and securely assembled. All suspended heads shall be provided with leveling hangers and balance adjusters. In addition, all signal head faces shall be aimed and secured in the direction of traffic they control.

Signal heads suspended from messenger cable and mast-arm suspended heads that are not rigidly mounted shall be attached directly to the cable or mast-arm hanger and balance adjuster. If approved by the Engineer, one head per span or mast arm may be lowered to the proper height by use of $1\frac{1}{2}$ in. galvanized steel piping connecting the signal head to the cable or mast-arm hanger. If piping is used, it must be painted to match the signal-head housing and a positive permanent means of securing the head to the pipe to prevent rotation shall be provided. In all cases, piping of signal heads should be avoided if possible.

All red sections of signal heads on a single span or mast arm shall be at the

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same elevation.

Optically programmed signal heads shall have a permanent, rigid mount fitting to assure reliable control of visibility. Programmed heads shall be aimed, fixed and programmed to control vehicle or pedestrian traffic only in the cut-off area specified on the Plans and as directed by the Engineer.

All type signal heads that are installed before a signal system is made operative shall be hooded with a black plastic material that will completely conceal the signal faces (even when lit) as well as cover the entire signal head. The material shall be weather resistant and fastened in such a way that it will be completely wind resistant.

660.11-CABINETS:

The cabinets for all types of traffic controllers or flasher units shall be mounted and installed at the location shown on the Plans and in accordance with typical installation details. No mounting holes or special outlets shall be made through the cabinet walls without the specific approval of the Engineer.

Adjustable steel bands or universal cabinet mounting bands shall not be used for mounting cabinets to poles or pedestals. Cabinets mounted on wood poles shall be attached with wood pole mounting brackets, secured with lag screws.

660.12-SUPPORT STRUCTURES:

Strain and mast-arm poles shall be installed with the amount of rake recommended by the pole manufacturer. The rake shall assure a substantially vertical set when the load is applied. For anchor base type poles, threaded adjusting nuts shall be used to establish the rake. The use of shims or other leveling devices is not permitted. Hardware and fittings shall be installed as shown on the manufacturer's installation drawings. When embedded or wooden poles are used, the rake shall be established as the pole is set.

Pedestal poles supporting only a vertical dead load shall be installed in a true vertical plane.

The Contractor shall take full responsibility for checking all cross sections to determine final support lengths.

660.13-MESSENGER CABLE:

When completely loaded the messenger cable, cable rings and conductor wire shall present a straight, clean, neat appearance. Excessive slack shall be pulled out of conductor wire and the ring supports shall be set at 15-in.(375 mm) centers.

Span wire sag shall be kept at a practical minimum and in no case exceed five percent of the span.

660.14-CONDUIT:

Conduit runs shown on the Plans may be changed to avoid underground obstructions with the written approval of the Engineer. Approximate lengths of conduit are shown on the Plans. The Contractor shall determine the exact

lengths of conduit in the field.

The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made square and true so that the ends will butt or come together for the full circumference thereof. Standard conduit couplings shall be used for joining all metal conduit. Slip joints or running threads will not be permitted for coupling conduit. However, expansion fittings shall be installed where the conduit crosses an expansion joint on a structure. Continuity through the expansion fitting shall be provided by means of # 6 AWG copper wire jumper. Conduit runs on the surface of structures shall be secured with galvanized malleable iron clamps spaced not more than 5 feet (1.5 m) apart.

The threads on all ferrous metal conduit shall be painted with rust preventative paint before couplings are made up. All couplings for metal-type conduit shall be tightened until the ends of the conduit are brought together, providing a good electrical connection throughout the entire length of the conduit run. Where the coating on metal conduit has been damaged in handling or installing, such damaged places shall be painted with an approved rust preventive paint. Exposed ungalvanized threads on metal conduit resulting from field cuts shall be painted with an approved rust preventative paint.

All metal-type conduit ends shall be threaded and shall be capped with a standard pipe caps until wiring is started. When caps are removed, the threaded ends shall be provided with conduit bushings.

Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are not used, conduit shall be bent, without crimping or flattening, using the longest radius practicable.

A # 12 AWG galvanized pull wire shall be installed in all conduits which are to receive future conductors. At least 2 feet (600 mm) of pull wire shall be doubled back into the conduit at each termination. All conduit runs shall be free of dirt, debris and excessive moisture before cable is pulled.

Existing underground conduit to be incorporated into the new system shall be cleaned with a mandrel or cylindrical wire brush and blown out with compressed air.

Conduit shall be laid to a depth of not less than 18 in. (450 mm) below finished grade in all areas, except that conduit may be laid on top of and secured to the existing pavement within new curbed medians being constructed on top of the pavement.

Rigid metal conduit shall be placed under existing pavement by approved jacking or drilling methods. Pavement shall not be disturbed without permission from the Engineer. In the event obstructions are encountered, upon approval of the Engineer, small test holes may be cut in the pavement to locate obstructions. Jacking or drilling pits shall be kept 2 feet (600 mm) clear of the edge of any type of pavement wherever possible. Water jetting will not be permitted.

Conduit terminating in pile or pedestal bases shall extend 4 inches (100

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mm) vertically above the foundation and shall be sloped towards the hand-hole opening. At all conduit termini, the conduit shall enter the outlet from the direction of the run. Conduit size shall be the same for terminal point to terminal point. No reducing couplings will be permitted.

If it is determined by the Engineer that it is impractical to bore the conduit under concrete or asphaltic pavement due to unforeseeable obstructions, the Contractor may, with the Engineer's permission, cut the existing pavement. The pavement shall be cut along neat and true lines by means of a concrete saw. The depth of the trench shall be as specified and the width shall be the minimum required for proper excavation and backfilling. The trenching operation, along with replacement operation, shall be performed according to Standard Detail TES-04. Concrete shall be allowed to set for a minimum of 49 hours without being exposed to traffic. At no time shall more than one-half of the roadway be closed for any conduit placement operations.

Conduit to be placed beneath railroad tracks shall comply with the following:

The conduit shall be rigid metal type, 2 in. (50 mm) minimum size and shall be placed to a minimum depth of 5 feet (1.5 m) below the bottom of the tie. The near side of each conduit jacking pit shall be constructed not less than 12 ft. (3.6 m) from the centerline of track. When the jacking pit is to be left overnight it shall be covered with substantial planking.

660.15-JUNCTION BOXES:

Junction boxes shall be installed at the locations shown on the Plans or, in long runs, they shall be spaced at not over 200 ft. (60 m) intervals. The Contractor may, at his own expense and with the approval of the Engineer, install additional junction boxes to facilitate his work.

The tops of junction boxes installed in the ground or in sidewalk areas shall be flush with the surrounding grade or pavement.

Concrete junction boxes shall be poured in place. However, pre-cast junction boxes may be used, when in the opinion of the Engineer, the surrounding subgrade has sufficient bearing qualities to support the box and cast iron frame.

All junction boxes shall be set on at least 12-in. (300 mm) bedding of aggregate base material as shown on the Plans. Grouting shall be done prior to the installation of conductors. No junction boxes shall be set on uncompact ground.

Concrete work shall be done in accordance with the applicable requirements of 660.8.

660.16-WIRING:

Sufficient five-conductor signal light cables shall be provided to perform the functional operation of the signal system and, in addition thereto, one spare conductor of a size equal to the largest signal light conductor in the run, except neutral, shall be provided throughout the signal light system.

No more than two signal heads shall be on the same conductor run. When

two signal heads are on the same conductor run, they must be of the same signal color sequence.

All signal light conductors shall be run continuously without splices from the terminal block located in a cabinet, compartment, or signal head, to a similarly located terminal block, unless otherwise specified on the Plans. Signal light conductors shall not run to a terminal block on a standard unless they are to be connected to a signal head that is mounted. All spare wires shall be placed on a special terminal block mounted in the controller cabinet for this purpose.

Five-conductor IMSA cable as specified shall be provided for all signal light circuits. This cable shall consist of red, orange, green, black and white insulated wires. The insulation color shall correspond as nearly as possible to the associated signal sequence color.

Permanent identification labels shall be attached to all controller and detector cabinet wiring to identify circuit and associated phase. Sequence color need not be identified if clearly indicated by conductor insulation color.

Wiring diagrams, detailing on one sheet all wires in the controller cabinet that are external to the controller itself, must be included with all signal systems. The diagrams must be complete and show all connections including switches, terminal block, connectors, relays and all other mechanisms in the cabinet. Other wiring for the controller shall be as required by the wiring diagrams and instructions furnished with the controller by the manufacturer.

Connection to each terminal of a pedestrian push button shall be by # 14 AWG single conductor in two-wire IMSA cable as required. The neutral for pedestrian push button circuits shall be separate from the signal light circuit neutral. Pedestrian push button circuits shall be limited to 12 volts AC or DC.

Conductors shall be pulled into conduit by hand. The use of winches or other power actuated pulling equipment will not be permitted. Powdered soapstone, talc, or other inert lubricants shall be used in placing conductors in conduit. When conductors are to be added to existing conductors in a conduit, all conductors shall be removed; the conduit shall be cleaned as provided in 660.14, and both old and new conductors shall be pulled into the conduit as a unit.

Where signal conductors are run in lighting standards containing high-voltage series street lighting conductors, either the signal conductors or the lighting conductors shall be encased in flexible or rigid metal conduit, to a point where the two type of conductors are no longer in the same raceway. Where telephone circuits are installed adjacent to signal and lighting circuits, the telephone conductors shall be encased in UL approved flexible metal conduit.

All wiring shall be installed in a neat and workmanlike manner. Conductors within fixtures or cabinets shall be cabled together with self clinching nylon cable ties, waxed lacing or other method permitted by the Engineer. Wiring within the controller cabinet shall be firm, neatly arranged and laced, or enclosed in plastic tubing or raceways. The finished wiring shall present a neat, clean appearance so that individual wires may be easily traced

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to their terminal points. Unnecessary slack in the conductor wires will not be permitted. Wiring workmanship shall be subject to the approval of the Engineer.

The ends of wires which are to be attached to terminal blocks of the barrier screw type shall be provided with solderless terminals that meet the requirements of the National Electrical Code. These terminals shall be the pre-insulated positive grip type. The terminal crimping tool shall produce a transverse crimp on the wire. Wires which insert into a positive wire insert type terminal block will not require terminals. No more than two conductors shall be brought to any one terminal.

On all pin and receptacle type connections, the receptacle shall be on the line side of the circuit.

Conductor splices may be permitted only in the following types of circuits at the following locations:

- i. Loop conductor and lead-in wire in junction boxes at traffic detectors.
- ii. In modified traffic signal systems where shown on the Plans (low voltage only).

Splices, where permitted, may only be made at points of access in conductor runs or raceways (handholes, junction boxes, etc.) and no splices shall be permitted in controller cabinets. All splices, with or without connectors, shall be soldered by the pouring or dipping method, except that soldering of pressure connectors and terminals may be omitted provided the connectors and terminals are applied with the proper type tool as recommended by the manufacturer of the connector or terminal being applied. Finished connections and terminals shall comply with the requirements of Military Specification MIL-T-7928. Splices shall be insulated by one of the following methods:

- i. Cast insulation of self-curing epoxy resin which is compatible with the wire insulation to form a moisture resistant joint. The resin shall be resistant to weather, with aromatic, straight chain solvents, and shall not sustain combustion. The resin shall be cured into molds of dimensions suitable for the splice.
- ii. A minimum of two thicknesses of electrical insulating pad, composed of a laminate of 0.085-in. (2 mm) thickness of electrical grade polyvinyl chloride and a 0.125-in. (3 mm) thickness of butyl splicing compound with removable liner. Pads shall be applied to the splice in accordance with the manufacturer's recommendations. The ends of the applied pad shall be wrapped with the polyvinyl chloride tape half lapped over the conductor insulation.
- iii. Heat shrinkable insulating tubing shall be applied after completing the splicing procedure shown on the Plans. Insulation over the connector shall consist of a heat shrinkable, mastic lined, heavy wall

polyolefin cable sleeve or cover, to which heat shall be applied at a temperature greater than 120EC until the sleeve or cover shrinks and covers the connector, and the mastic material has flowed completely around the cable to form a waterproof insulation.

Electrical tape shall be UL approved and be one of the following types:

- i. Self-fusing, oil and flame-resistant, synthetic rubber.
- ii. Pressure sensitive, adhesive, polyvinyl chloride, 0007 in. (178 μ m) minimum thickness.

Where polyvinyl chloride tape is used for a final layer, an electrical insulating coating shall be used which shall be fast drying, resistant to oil, acids, alkalies and corrosive atmospheric conditions and compatible with the tape.

All splices shall be noted on the Plans and approved by the Engineer.

Unless otherwise specified, shown on the Plans or directed by the Engineer all signal system conductors shall run continuous and unspliced from terminal to terminal. Signal system conductors shall include but not be limited to power service wires, signal circuit conductors, controller panel wiring, controller wire harness, loop lead-in and loop wire. System interconnect cable shall be continuous and unspliced from controller cabinet terminal to controller cabinet terminal.

660.17-POWER SERVICE:

The power connection shall be made to a single-phase 120/240 volt, three-wire, 60Hz, AC supply. The approximate location of utility service points may be shown on the Plans; however, the Contractor shall determine the exact location of the power supply. Each signalized intersection or control unit shall have a separate power service and no more than one power service shall be utilized per intersection or unit.

Electrical service installation and materials shall conform to the requirements of the serving utility. The service equipment shall be installed as soon as possible to enable the utility to schedule work well in advance of the completion of the project.

Enclosed circuit breakers, external to the controller cabinets, shall be provided in the power service. Four singlepole breaker units rated at 30 amps each are required. The breaker enclosure shall be weathertight with a top hinge cover, hasp for sealing cover and provisions for padlocking the cover. The Contractor shall provide an all-weather padlock and two sets of keys with each power service. Circuit breakers shall be approved and listed by the Underwriter's Laboratory.

Breakers # 1 and 2 shall provide power for the signal control equipment (controller cabinet). Specifically circuit breaker # 1 shall power the controller circuits and # 2 shall power the flasher and associated circuitry. These two

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circuits must be of the same polarity. Breakers # 3 and 4 are spare terminals to accommodate future lighting circuits and breakers 3 and 4 must be of opposite polarity to provide a 240 volt circuit.

The Contractor shall make all arrangements for connection to the power supply and shall obtain a meter and meter socket from the power company at the time these are required. The Contractor shall furnish, install, pay installation fee and provide all materials necessary for the power connection not provided by the power company.

All external power service wiring from the service head or service point on shall be enclosed in rigid metal conduit; this includes equipment ground wires.

When complete and in place the power service shall provide in the signal controller cabinet, two separate fused 120 VAC, 60 Hz power sources rated at 30 amps each of the same polarity or phase.

660.18-TESTING:

660.18.1-Operational Field Tests: Upon completion of the installation of a traffic signal system, operational field tests shall be run on each and every part of the system. After the initial field tests are run satisfactorily, the Contractor shall conduct a continuous 12-hour operating test for approval.

Upon successful completion of the 12-hour test and with the approval of the Engineer, a 30-day test period will then be initiated. Final acceptance of an installation will not occur until 30 days of system operation are completed and termed satisfactory by the Engineer.

A final inspection may be conducted by the Division at any time prior to completion of the 30-day test. At the option of the Engineer, equipment found to be defective during this inspection may warrant the renewal of the full or any part of the operational test period.

In addition, the Contractor shall be responsible for equipment malfunctions that occur during any test period. The Contractor shall repair or replace any defective equipment within 24 hours after being notified by the Engineer. After the repair has been effected, the Engineer may at his option renew any or all of the operational test period.

660.19-METHOD OF MEASUREMENT:

660.19.1-Signal Controllers: Signal controllers shall be measured as a complete unit in place by intersection or control location. This item shall consist of the complete electrical mechanism for controlling the operation of traffic control signals, including the timing mechanism and all necessary auxiliary equipment mounted in a cabinet or other enclosure.

Included under signal controllers shall be traffic adjusted master controllers and computers and associated equipment. This item shall include cabinets or other enclosures as required.

660.19.2-Traffic Detectors: Traffic detectors shall be measured per unit complete and in place, mounted in a cabinet or enclosure as required. This item

shall consist of the detector tuning unit only. Roadway traffic sensors such as loops, probes, etc. shall be considered "Miscellaneous Signal" items. Cabinets or other enclosures as required for the detector tuning units shall also be included in "Miscellaneous Signal".

660.19.3-Signal Sections: Signal heads shall be measured complete and in place by signal head section. Red, yellow, green, arrow and walk-don't walk signal sections shall be considered complete when assembled on the support structure in accordance with the signal head configuration shown on the Plans. Both vehicular and pedestrian heads shall be included in this item. In addition, this item shall include all the necessary hardware for mounting the signal heads to the support structures. Optical programming shall be included in this item.

660.19.4-Signal Supports: Signal supports shall be measured as a complete unit in place, per mast arm structure or per pole support, including foundation. This item includes guys, messenger cable and anchor bolts for support structures, but does not include such items as controller cabinet mounting brackets and signal head mounting hardware covered in other sections.

660.19.5-Junction Boxes: Junction boxes shall be measured as a complete unit in place. This item includes aggregate base, concrete, iron frame and cover as required. All junction boxes shall be included under this item both units constructed for the signal system as well as those required for the signal interconnect.

660.19.6-Signal Interconnect: Signal interconnect shall be measured as a complete unit in place per interconnected system. This item includes most of the materials and construction related to the signal interconnection system only. Supports and wire-ways constructed primarily for other purposes shall not be included in this item. Conduit, support structures, support hardware wire and messenger cable installed solely for the interconnect system shall come under this item. This item shall not include coordinating units or interconnect system junction boxes.

660.19.7-Miscellaneous Signal: Miscellaneous signal items as required to complete a traffic signal system in accordance with the Plans or these Specifications shall be measured complete in place by intersection or control location. This item shall include but not be limited to power services, electrical conduit, vehicle sensors (loops, probes, etc.), pedestrian push buttons and all wiring, appurtenances and work not included in other Contract items.

660.19.8-Signal Removal: Signal removal shall be measured as a complete unit by intersection. It shall include the furnishing of all necessary equipment and labor to adequately remove the existing signal equipment as

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necessary to meet the requirement of the Plans. The existing roadway and traffic control devices shall be maintained or revised as required during construction to assure the safe and expedient movement of traffic (See 660.4).

660.20-BASIS OF PAYMENT:

660.20.1-General: When accepted as complete, the quantities determined as provided above will be paid for at the contract unit price bid for the items listed below, which prices and payments shall be full compensation for furnishing all materials and doing all the work prescribed in a workmanlike manner, including excavating, backfilling, replacing sidewalks and pavements, replacing curb and gutter, disposal of waste and debris and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Unit bid prices shall be submitted as indicated on the Plans per code unit, type or intersection number.

660.20.2-Traffic Detectors: Pay item codes shall be as follows:

(LPS)-Loops

(PBS)-Probes

660.20.3-Signal Sections: Pay item codes shall be as follows:

(V-8)--8" ((V-203) --203 mm) Vehicle Signal Sections (R, Y or G)

(V-12)--12" ((V-305) -- 305 mm) Vehicle Signal Sections (R, Y, G or ARROW)

(V-8P)--8" ((V-203) --203 mm) Programmed Vehicle Signal Sections (R, Y or G)

(V-12P)--12" ((V-305) -- 305 mm) Programmed Vehicle Signal Sections (R, Y, G or Arrow)

(P-9)--9" ((P-229) -- 229 mm) Pedestrian Signal Sections (W-DW)

(P-12)--12" ((V-305) -- 305 mm) Pedestrian Signal Sections (W-DW)

660.20.4-Signal Supports: Pay item codes shall be as follows:

(Type)--Poles and Mast Arms

(PED)--Pedestal

660.20.5-Junction Boxes: Pay item codes shall be as follows:

(Type)--H or L

660.20.6-Signal Removal: Payment for traffic signal removal shall be in accordance with one of the following:

- i. If there is a pay item in the Contract for Signal Removal, the Contractor shall remove the equipment as specified and payment shall be one lump sum, per intersection basis.
- ii. If there is not a pay item in the Contract for Signal Removal, and removal is required for completion of the Contract, existing signal

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equipment shall be removed by the Contractor unless otherwise specified. No additional compensation will be paid and removal work as well as salvage value of equipment if applicable, shall be considered in the bid price for “Miscellaneous Signal” items.

Removal and disposition of salvaged equipment shall be in accordance with 660.5 of these Specifications.

660.21-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
660001-*	SIGNAL CONTROLLER	LUMP SUM
660002-*	TRAFFIC DETECTOR, “type”	EACH
660003-*	SIGNAL SECTION, “type”	EACH
660004-*	SIGNAL SUPPORT, “type”	EACH
660005-*	JUNCTION BOX, TYPE “type”	EACH
660006-*	SIGNAL INTORCONNECT	LUMP SUM
660007-*	MISCELLANEOUS SIGNAL	LUMP SUM
660008-*	SIGNAL REMOVAL	LUMP SUM

* Sequence number